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there seems no good reason for believing that spraying, even with the most improved methods with which we are now familiar, would be practicable or profitable on a large scale. At Garrett Park, where this kind of work was done with the greatest care and where every precaution was taken to make the various preparations cover the foliage, rust was just as abundant on the sprayed as on the unsprayed wheat. A critical study of the plants in the field afforded what seems a satisfactory explanation of the foregoing fact. On examining the leaves immediately after they had been sprayed in the most careful manner, it was found that fully one-half of the surface was wholly free from any signs of the liquid put on. The shape of the leaf, its position on the stem, manner of growth, and waxy covering, all conspire to render it exceedingly difficult to wet, and unless thoroughly wetted or covered by the fungicide there is little hope of preventing the reproductive bodies of the rust fungi from gaining an entrance.

Finally, it may be said that while improved machinery and fungicides and improved methods may make it possible to profitably spray our cereals, with our present means this can not be done. The work, however, should not be abandoned; on the contrary, it should be continued until the matter is definitely settled one way or the other. At the same time the far more promising work of breeding rust-resisting varieties should be taken up and carried forward along such lines as offer the most promising results.

ADDITIONAL NOTES ON PEACH ROSETTE.

By Erwin F. Smith.

I.—SPREAD OF THE DISEASE.

The peach rosette continues in Georgia and has appeared in South Carolina. Mr. W. L. Anderson, of Ninety-six, sent specimens from his peach orchard, and wrote as follows, under date of June 14, 1892:

> In the summer of 1890 I noticed some of the peach trees turning yellow; but, from information at hand, concluded it was not what is called the yellows. The trees (3) died, root and branch. No sprouts have ever put forth from the old roots of any of these or other trees since attacked. Last year I lost 6 trees from the same disease. This year I cut down 8 as soon as I noticed the peculiar growth of the leaves. I have 2 left, some one-fourth mile apart. They are, at this writing, evidently moribund and will be dead in another month.

Mr. Anderson states that several of his neighbors have lost trees, and that the disease is entirely new to him, although he has lived in that region and been interested in peach-growing for a long time.

Some field work begun in Georgia in 1890 and 1891, could not be reported upon fully in Bulletin 1,* because incomplete or only just begun when that report went to press. A year has passed and certain additional conclusions may now be drawn with confidence.

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*Div. Veg. Pathology, U. S. Dept. of Agr., 1891.

The experiments are as follows:

II.—FIELD EXPERIMENTS IN GEORGIA.

I. *Peach on Marianna plum stock—Buds from the healthy-looking side of a rosetted peach tree.*—This experiment was made to determine whether the disease was latent in the healthy-looking side of the affected trees, and would afterwards appear in buds cut from the same and inserted into healthy stocks. The buds were set July 1, 1890. The condition up to the fall of 1891 of the trees grown from these buds is given under Experiment 2 (Bull. No. 1, p. 56). These trees were reëxamined October 31, 1892. All of them were still free from rosette. The buds have now been set twenty-eight months and have grown into vigorous tops, so that there can no longer be any doubt that the north part of the parent tree was entirely free from taint of disease at the very time that the south part was badly affected. The rest of this tree became diseased the following season and is now dead.

II. *Marianna plum stocks inoculated with buds taken from rosetted peach trees.*—This experiment was made to determine whether the peach and plum rosette are identical. For this experiment and the next about 250 trees were selected from 5 nursery rows on the farm of William Warder, Griffin, Ga. These trees were propagated from cuttings and were 1½ years old at the beginning of the experiment. Two rows were inoculated and 3 were held for comparison. June 8, 1891, 104 of these trees were inoculated with buds cut from 6 or 8 of the badly rosetted young trees described in Experiment 1 (Bull. No. 1). One to two buds were inserted into each tree in the usual way. November 13, 1891, all were free from rosette. At that time the condition of the inserted buds was as follows: In 42 trees the buds had healed on and were still alive in whole or part, but only 2 had grown into shoots, and both were feeble—only ½ and 1 inch long. In 2 or 3 trees the unions were doubtful. In the rest the buds failed to unite with the stocks. There is no question, therefore, but that in more than one-third of the trees an organic union had taken place between the plum stocks and the rosetted buds. Only five months had elapsed and it was thought that perhaps a longer period might be necessary to infect plum from peach than had been found necessary in case of peach on peach. These trees were reëxamined November 1, 1892, *i. e.*, more than sixteen months from the date of inoculation, and all were still free from rosette. There is, therefore, good reason to believe that the Marianna plum is not subject to this disease.

III. *Marianna plum stocks inoculated with buds taken from a rosetted Kelsey plum.*—This experiment was made to determine whether the plum rosette could be transmitted to plums. The trees used for these experiments formed part of the block described under II. The buds were inserted the same day under like conditions. They were taken on the Wayman farm, from a Kelsey plum which was badly affected in all parts. Only 12 trees were budded. On November 13, 1891, it was found that the diseased buds had healed on to 4 trees, and were still living. On the others they had been thrown out. There were no cases of rosette. The trees were reëxamined November 1, 1892. All were free from rosette. This is the only experiment yet undertaken to determine whether this disease can be transmitted from plums to plums.

IV. *Peach stocks inoculated with buds taken from rosetted Kelsey plums.*—This experiment was made to determine whether the plum rosette could be transmitted to peach trees. Two rows of nursery trees, 37 in all, consisting of Elberta tops on seedlings of the same age as in V, were selected for this experiment. This formed part of the nursery described in Experiment 1 (Bull. No. 1). Scions were cut from two badly diseased Kelsey plums, which stood on the same farm about ½ mile distant. The inoculations were made June 20, 1891, and two buds were inserted into each stock. November 12, 1891, an examination showed that some part of one or both buds had united with the stock in 22 cases, and was still alive. In 3 trees the union was doubtful, and in 12 both buds failed to unite. At this date all were healthy with exception, possibly, of 1 tree, which had begun to look suspicious. The inoculated buds were very feeble, and in no case did they grow into branches. Here, then, an organic connection was established between the buds and stocks in two-thirds of all the trees. October 29, 1892, these trees were reëxamined with the following result: Many of the buds which had healed on were still alive. Two trees were dug out in summer, and may have shown symptoms of rosette, but this is doubtful. One of these was the tree marked as suspicious in the fall of 1891. Two trees developed rosette in the spring, in all parts, and died in August. The rest were healthy in spite of the fact that sixteen months had passed since the insertion of the diseased buds. Both the rosetted trees were inoculated from the same plum; both the missing trees from the other plum.

The small per cent of cases to unions makes it necessary to repeat this experiment before it can be stated positively that the plum disease is identical with that of the peach and transmissible to it, as seems very probable from its appearance.

V. *Root inoculations, peach on peach.*—This experiment was made to determine whether the disease could be transmitted from roots to roots, and incidentally to throw some light on the possibility of natural infection through the soil. Sixty young trees were selected for this purpose. They stood in the same nursery and were planted the same time as the five rows inoculated in 1890 and described in Experiment 1 (Bull. No. 1, p. 49), but bore Elberta tops. The collars of the trees in two rows were uncovered and all trees badly infested by borers were destroyed.

The remainder were then inoculated, June 20, 1891, as follows: The earth was carefully removed from one of the roots and a T-shaped incision was made down to the pericambium. A root about ¼ inch in diameter was then selected from a rosetted tree and a curved cut made through the bark down to the pericambium, parallel to it for about an inch, and then out again, in some cases including a thin shaving of wood. This graft was then crowded beneath the lips of the T-shaped cut and bound into place. The earth was then returned. These root grafts came from 15 badly rosetted trees, and each one was taken from a separate root. Each tree furnished 4 grafts, making a total of 60. Presumably all of these roots were diseased, but such is not known to be the case. The inference rested on the fact that all of the leaves and shoot-axes were rosetted on each of the 15 trees. Nine of these trees were from Experiment 1 (Bull. No. 1), being seedlings in which the disease had been produced by the previous year's bud inoculations. The other 6 trees stood in a neighboring orchard, were 5 or 6 years old, contracted the disease naturally, and had been entirely healthy until the spring of 1891. The bark of the roots being much thicker than that of stems of the same size, considerable difficulty was experienced in getting the grafts into place, and consequently it was somewhat doubtful whether they would unite with the stock.

These trees were examined November 12, 1891, *i. e.*, four months and twenty-two days after the inoculation. All were free from rosette and healthy.* They were reëxamined October 31, 1892. The conditions above ground were as follows: Seven trees were rosetted in all parts and already dead, 52 trees were healthy, 1 had been killed by borers and termites. All of the rosetted trees were grafted from the artificially infected young trees. The 24 trees grafted from the naturally infected orchard trees remained sound. Three of the 7 rosetted trees were grafted from 1 tree, the other 4 were grafted from 4 other trees, making five sources of infection. After the above-ground conditions had been determined, the roots of each of the 60 trees were dug out, washed, and carefully examined. Although the grafting had taken place more than sixteen months previous, it was not difficult to find the scar, and in most cases the inserted graft was still in place. The result of this examination may be summed up as follows: In the 7 rosetted trees the inserted graft had healed on and become an organic part of the root. In 5 healthy trees a very small fragment of the graft may have healed on, but this was doubtful, and can only be settled, if at all, by microtome sections and a careful study. The remainder of the graft was unquestionably thrown out. In the rest, the inserted grafts wholly failed to unite with the root, but were generally in place in a shriveled or semi-decayed condition, the roots having healed under them.

The symptoms appeared on the rosetted trees in the spring—April or May. All of them showed symptoms at once in all parts, and all died in August. There were and have been no cases of rosette in the rest of the young Elbertas (about 4,000); there was only one case in that part of the orchard joining this nursery, and there were less than last year in the other orchards on this farm, *i. e.*, about 27 in a total of 10,000 trees. This makes it overwhelmingly probable that the results here detailed are to be ascribed to the inoculations and not to any outside influence.

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* In case of the above-ground inoculations of Experiment 1 (Bull. No. 1), more than 50 per cent of the trees developed symptoms in four months and twelve days.

This experiment is especially interesting for a number of reasons:

(1) The disease has now been communicated from artificially infected trees to healthy ones, *i. e.*, the infection has been carried a second remove from the orchard trees which were its original source. (Bull. No. 1.)

(2) The rosette can be communicated from root to root as well as from stem to stem.

(3) The root-inoculated trees did not develop symptoms as soon as those which were inoculated above ground the preceding year, probably because the contagion had a longer distance to travel through the tissues.

(4) The small per cent of infections in comparison with the results of 1891 (Bull. No. 1) is attributable to the smaller number of unions. There were unions on only 12 trees at most and the disease followed in every case where from one-half to the whole of the graft became firmly united to the root.

(5) In case of the five doubtful unions the grafts came from as many different trees, and it is possible that these fragments may not have contained the infectious material even if any part really united with the roots, which is also a matter of doubt.

(6) In the other 52 trees, as in 4 trees of Experiment 1, (Bull. No. 1), simple contact failed to induce the rosette, although in all cases the diseased tissue (young prosenchyma and pericambium) was bound down tightly on to the meristem of the root, and in several instances was found to have been inclosed and tightly squeezed, and even deeply buried between the growing tissues of the root.

VI. *Inoculations of young peach trees with micro-organisms derived from cultures.*—These experiments were made to determine whether micro-organisms were constantly or commonly present in diseased tissues, and whether pure cultures of any of them would induce the rosette. Numerous tube and plate cultures from rosetted trees were made at Griffin, Ga., by W. T. Swingle and myself, in the summer of 1891, with as great care as our limited facilities would permit. A number of interesting yeasts and bacteria were isolated from the tissues or appeared in the cultures as contaminations. Notes were made on the manner of growth and microscopic appearance, stained and unstained, of all these forms—about twenty—and pure cultures from the original colonies were used for purposes of inoculation.

A series of 20 young trees was inoculated on the farm of H. W. Hasselkus, east of Griffin, and a duplicate series was inoculated on the farm of J. D. Husted, at Vineyard. Some of the more promising organisms, *e. g.*, those which grew but feebly on the agar or gelatine, and those which occurred in the cultures most frequently, were also inserted into a row of young trees in the garden of Mr. Hasselkus in Griffin. Each tree was inoculated on the main axis above ground in three places and in three slightly different ways, as follows:

(1) A T-shaped slit was made through the bark, and one flap was separated from the cambium and slightly lifted. A mass of the organisms was then removed from the culture on the loop of a platinum wire and inserted into the wedge-shaped cavity between the wood and bark. The latter was then bound securely in place.

(2) Into a similar slit a bud cut from the same tree was inserted and bound in place as in ordinary budding, the inner bark of the bud having first been carefully smeared with the micro-organisms, so that bark of insert and wood of stock were brought into close contact with a thin layer of germs between.

(3) The third inoculation was made in the same way, *i. e.*, the inner surface of the insert was smeared with the germs, but the wood of the bud was not removed.

The platinum wire was flamed before each inoculation, and the work was carried on as rapidly and deftly as possible to avoid contaminations. The inoculations were made in Mr. Hasselkus's yard June 15 and 16, on his farm June 19, and at Mr. Husted's place June 22, 1891. These trees were examined in the fall of 1891, and again in the fall of 1892. None of them developed rosette or any symptoms suggestive of it. In some cases there was considerable swelling and flow of gum at the points of inoculation, but none of the trees died or became sickly. All of the trees made a good growth, and those belonging to Mr. Hasselkus grew enormously. Of course many of the buds were thrown out, but others healed on in spite of the coating of micro-organisms.

An experiment was also tried using scrapings and bruised fragments of diseased tissues as infective material, but it was in old trees on a small scale, and the results are not conclusive enough to make it worth reporting.

III.—CONCLUSIONS RELATIVE TO THE NATURE OF THIS DISEASE.

(1) Excluding a few doubtful cases, the disease was conveyed from peach to peach whenever an organic union took place between the diseased buds and the healthy stocks (two experiments—128 trees).

(2) In no case was the disease transmitted artificially by mere contact even when meristem was bound very closely to meristem (two experiments—56 trees).

(3) From the failure to induce rosette by simple contact it is prob-

able that the contagion does not enter the tree through ordinary wounds caused by men or animals.

(4) The fact that the disease can be transmitted artificially through the root system makes it probable that trees may also become infected naturally in this way.

(5) Experimental proof of the identity of the peach rosette and the plum rosette is still incomplete.

(6) None of the yeasts or bacteria found in the cultures made from diseased tissues produced the disease when inserted into the cambium, and it is probable that the disease is not due to such organisms.

(7) In both natural cases and those induced by budding, the disease progresses gradually from the point of infection until all parts of the tree are involved. Even when a tree shows symptoms in all parts at once, as is very often the case in early spring, we may assume that the cause of infection entered through the roots during the previous summer or autumn and was gradually diffused through the whole tree in the months immediately preceding the vernal symptoms, as was certainly the case in the seven root-grafted trees.

(8) The shortest period of incubation was about two months (Bull. No. 1, p. 49) and the longest period about ten months, but one-half of this longest period was the winter season, during which the trees were dormant.

(9) The disease is probably conveyed through the protoplasm and the failure to isolate any pathogenic yeast or bacterium suggests the possibility that the cause is some amœboid organism living in the protoplasm and so much resembling it as to be difficult of detection. Such an hypothesis would explain all the facts. That the disease is due to any chemical ferment or other readily soluble substance seems out of the question, for the upward and side movements of the water imbibed by the roots would certainly carry it to all parts of the growing tree within a few hours or a few days at longest. Moreover, such a substance possesses no indefinite power of multiplication. Whereas, in this disease a very small fragment will induce symptoms in a whole tree, any part of which will then induce the disease in another tree.

REMEDIES FOR THE ALMOND DISEASE CAUSED BY CERCOSPORA CIRCUMSCISSA, SACC.

By Newton B. Pierce.

[Plates xviii-xx.]

Since the publication of the author's former paper on the almond disease so prevalent in southern California,* spraying experiments have been conducted in Orange County, which have clearly demon-

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